Tailored cricoplasty: An improved modification for reconstruction in subglottic tracheal stenosis

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Objective: Subglottic laryngotracheal stenosis with side-to-side narrowing poses a challenge for successful reconstruction. The standard technique of anterior cricoid resection was modified to address a small ventricle with lateral narrowing.

Methods: This study was a retrospective chart review and telephone questionnaire follow-up of consecutive patients with subglottic stenosis at a single institution. Follow-up questionnaires used Likert scales (ratings 1–10) to describe preoperative and postoperative symptoms, satisfaction, and perceived effectiveness. Once the anterior cricoid is removed, resection of thickened submucosal tissue is performed. The inner third to half of the lateral wall of the remaining cricoid cartilage is carefully excised. Advancing the preserved mucosa over the cricoid resurfaces the exposed cartilage. This results in additional horizontal enlargement of the luminal diameter of the airway of 3 to 5 mm.

Results: Eighteen patients with subglottic stenosis, small laryngeal ventricle, and lateral narrowing underwent tailored cricoplasty during a 15-month period. Mean age was 51 years (range 20–75 years), and mean follow-up was 9.1 $\pm$ 1.2 months (range 2–17 months). There were 2 self-limited airway complications. All patients reported that they were satisfied and would undergo surgery again. Overall satisfaction was rated at 9.5 $\pm$ 1.0, and satisfactions with resting and exertional dyspnea were 9.7 $\pm$ 0.5 and 9.5 $\pm$ 1.0, respectively. Symptoms of recurrence at follow-up were rated as 0.6 $\pm$ 1.4.

Conclusion: Tailored cricoplasty is an effective technique to improve the outcome of reconstructive subglottic stenosis. It offers reconstructive possibilities for patients with diminished side-to-side dimensions in the subglottic airway.

Benign subglottic laryngotracheal stenosis can occur as a result of intubation, tracheostomy, trauma, inhalational burns, irradiation, infection, Wegener granulomatosis, or, more commonly, idiopathic, inflammatory causes.[1] Stenosis of the subglottic larynx presents the greatest challenge for tracheal resection and reconstruction. The subglottic larynx is a challenge because it is the narrowest segment of airway and is in proximity to the vocal cords and recurrent laryngeal nerve insertion. Furthermore, these lesions are often associated with side-to-side or lateral narrowing of the subglottic space (Figure 1), which makes the luminal diameter tight after anastomosis and often leads to unsatisfactory symptomatic relief. When the laryngeal ventricle is adequate, single-stage resection as described by Grillo[1] has achieved good results.[1-5] When the ventricle is small and the lateral aspects are narrowed from side to side, success with standard techniques may be unpredictable, so this presentation has been a relative contraindication to reconstruction in some cases.

There have been many suggested reconstructive possibilities for the treatment of subglottic stenosis. These have ranged from repeated laser resections and dilations, to resection and reconstruction, to cartilage interposition into the cricoid.[1,2,5-9] The small laryngeal ventricle is a combination of increased submucosal thickening and narrowed side-to-side or lateral dimensions of the cricoid cartilage. Conventional techniques do not address these findings. The original procedures described by Grillo[1] and by Pearson and colleagues[7] provide excellent results when the stenosis is concentric; however, they do not address lateral narrowing in the subglottic space. These procedures involve the resection of the anterior cricoid cartilage, with or without resection of the posterior cricoid plate and resurfacing with a membranous wall flap from the distal resection margin. In theses procedures, the lateral cricoid cartilage is not removed to protect the recurrent laryngeal nerves.

We propose a modification of the single-stage subglottic resection and reconstruction of Grillo to improve results when a small laryngeal ventricle and lateral narrowing coexist. This report describes our experience with this challenging group of patients.

MATERIALS AND METHODS

Study Design

This study consisted of a retrospective chart review and telephone questionnaire follow-up of consecutive patients with proximal subglottic stenosis and lateral narrowing of the subglottic space treated with tailored cricoplasty at a single institution (Massachusetts General Hospital, Boston, Mass) from February 2006 to April 2007. This series represents the results of surgical correction for the first 18 patients who underwent the procedure from its inception and introduction into clinical use in February 2006.

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Abbreviation and Acronym
ANCA = antineutrophil cytoplasmic antibody

Records of patients who had undergone tracheal resection and reconstruction were drawn from a prospectively accrued thoracic surgery database, and operative reports were reviewed to determine which patients had undergone tailored cricoplasty. A single surgeon performed all procedures. The institutional review board at the Massachusetts General Hospital approved the study protocol.

Online medical records, operative reports, and hospital charts were reviewed to abstract demographic, preoperative, intraoperative and postoperative data concerning patients who had undergone cricoplasty. Patients were contacted by telephone and were administered a follow-up questionnaire to assess subjective responses to surgery.

Follow-up study questionnaires used Likert scales (ratings 1–10) to describe preoperative and postoperative symptoms, satisfaction, and perceived effectiveness. A score of 0 signified extreme dissatisfaction or ineffective therapy, whereas a score of 10 signified extreme satisfaction or effectiveness. Results are reported as means, medians, ranges, and SDs. The paired sample *t* test was used to compare means before surgery and at follow-up.

Surgical Technique

All patients were treated with a single-staged laryngotracheal resection with primary end-to-end anastomotic reconstruction. Patients with very high stenosis and lateral narrowing underwent a modification of the standard technique of anterior cricoid resection—tailored cricoplasty—to allow increased postoperative lateral luminal airway diameter. The decision to perform cricoplasty was made intraoperatively, after the trachea was opened, so that the stenosis could be properly assessed from the inside. The procedure was only performed in patients without adequate inner luminal area after standard laryngotracheal resection.

In this procedure, the anterior cricoid is removed as described by Grillo and colleagues.[3] The decision to resect the mucosa from the posterior plate of the cricoid depends on how abnormal it is. If the mucosa is resected, a membranous wall flap is created to resurface the posterior cricoid. The trachea is beveled to fit the thyrocervical anatomy. Once the anterior cricoid has been removed (Figure 2), sharp submucosal resection of thickened submucosal tissue is performed laterally with a scalpel (15 blade). It is mandatory to preserve the mucosa for subsequent resurfacing. The thickened submucosal tissue is usually 3 to 4 mm in width. The inner third to half of the lateral cricoid cartilage is carefully excised (Figures 3 and 4). It is important not to thin the cartilage too much, to avoid compromising the structural integrity of the cricoid. The mucosa overlying the resected cartilage is preserved as a pedicled flap (Figure 5). The exposed cricoid cartilage is resurfaced by advancing the preserved mucosal flap over the cricoid and suturing with interrupted 5-0 chromic sutures (Figure 6). Sutures are placed in a simple interrupted manner through the mucosal flap, pulling the flap to cover the exposed cartilage and then through the remaining cricoid. The knots are tied on the outside of the airway.

Resurfacing is performed to prevent exposed cartilage within the airway and minimize granulation tissue. These modifications result in an additional horizontal enlargement of the luminal diameter of the airway of 4 to 5 mm in most patients. After cricoplasty, interrupted 4-0 Vicryl (Ethicon, Inc, Somerville, NJ) end-to-end anastomosis is performed with techniques previously described.[1,2,4,5] All patients are maintained in neck flexion for 7 days and undergo flexible bronchoscopy before discharge to evaluate the adequacy of the airway. To decrease postoperative laryngeal edema, patients are placed on voice rest. In addition, they do not receive anything by mouth for 72 hours to decrease movement of the larynx and avoid aspiration.

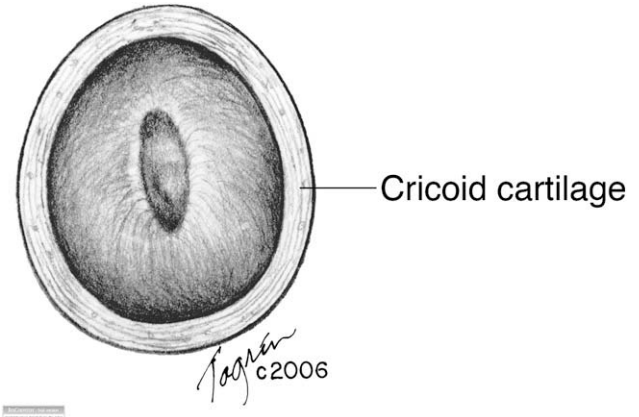

FIGURE 1. High laryngotracheal subglottic stenosis with side-to-side narrowing. View is from below looking up at stenosis during surgery.

RESULTS

Eighteen patients (17 female and 1 male) underwent tailored cricoplasty during a 15-month period. There were a total of 45 tracheal resections during that period. Three resections were performed for postintubation tracheal stenosis, and 15 were performed for idiopathic subglottic stenosis. Mean age was 51 years (range 20–75 years,) and none of the patients were current smokers. Mean duration of symptoms before resection was 4.4 ± 4.5 years. All patients had negative results for antineutrophil cytoplasmic antibody (ANCA), and 4 patients had positive results for antinuclear antibody. The average number of tracheal rings resected (excluding cricoid) was 2.5 (range 1–4). All patients were extubated in the operating room, and mean hospital stay was 8.3 ± 1.6 days.

Table 1 outlines the preoperative demographic characteristics of the sample. None of the patients in the study were receiving steroids at the time of surgery. One patient had failure of a previous tracheal resection and reconstruction performed at another institution.

Table 2 describes the postoperative complications. No patient required reoperation, tracheostomy, or readmission to the hospital during the entire follow-up period. There were no in-hospital or 30-day deaths, nor had there been any deaths at time of follow-up. Median and mean intensive care unit stays were 1.0 and 1.2 ± 0.7 days, respectively. Median and mean hospital stays were 8.0 and 8.3 ± 1.6 days, respectively.

There were 6 complications in 5 patients (27.8% of patients). Two of these patients had airway complications. The first patient had postoperative stridor as a result of mucosal edema, which was successfully managed with parenteral steroids (dexamethasone [Decadron] at 10 mg intravenously initially, then 4 mg every 8 hours for 3 days). The second patient required reintubation after surgery. This patient had undergone laryngotracheal resection and reconstruction for idiopathic subglottic stenosis. She had

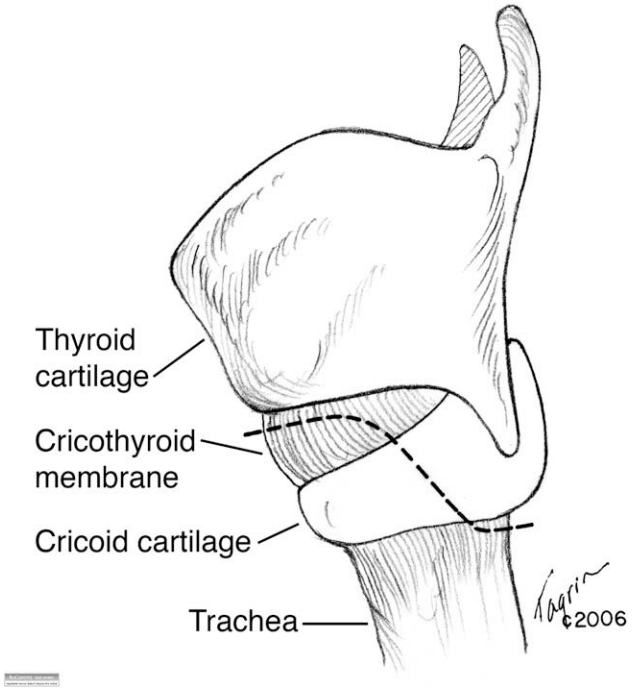

FIGURE 2. Cricoplasty, step 1. Anterior cricoid plate is removed.

an uneventful initial postoperative course. On postoperative day 7, the patient underwent flexible bronchoscopy and was found to have a well-healed, patent, and intact anastomosis. Two hours after leaving the operating room, she however, took a shower in her hospital room and became acutely dyspneic with oxygen desaturation in the range of 80%. Of note, she had a history of numerous allergies and had used a new shampoo in the shower. An erythematous rash developed over most of her body. She was rushed back to the operating room and intubated over a pediatric bronchoscope.

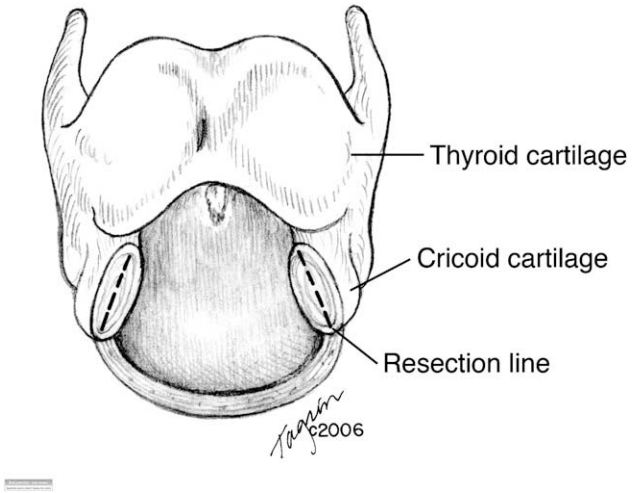

FIGURE 3. Cricoplasty, step 2. Inner third to half of lateral cricoid cartilage is carefully excised.

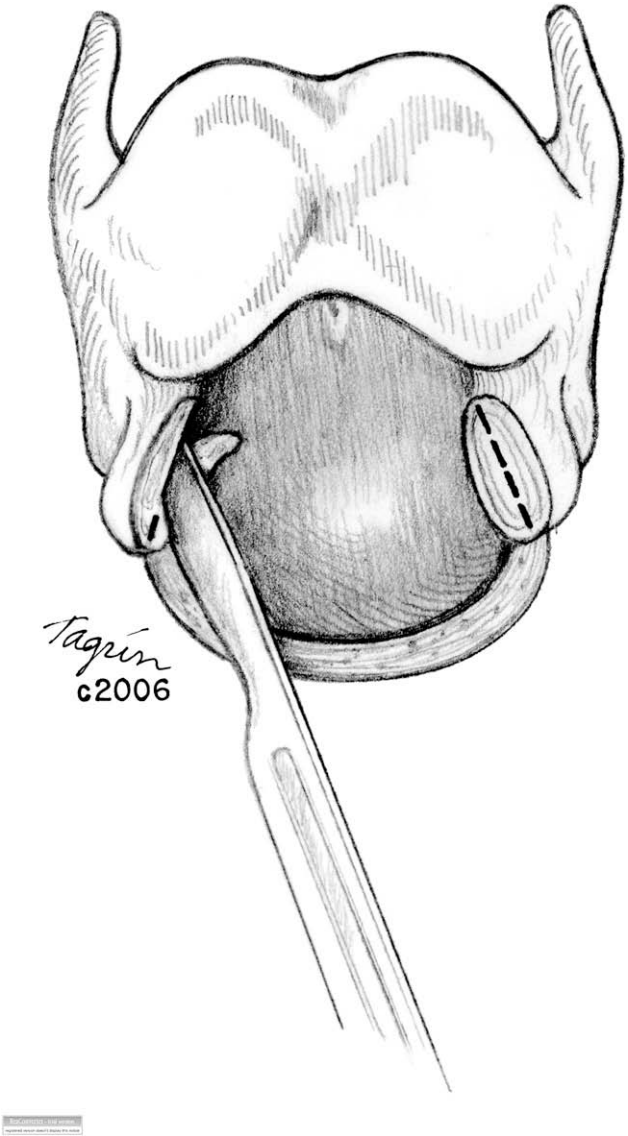

FIGURE 4. Cricoplasty, step 2. Manner of lateral cricoid resection. Scalpel is used to shave off pieces of thickened submucosal tissue bilaterally at lateral cricoid.

Her airway was pinpoint. She received intravenous steroids and antihistamines, was extubated successfully 24 hours later, and remains well and without complications at follow-up.

The mean follow-up time to questionnaire administration was 9.1 ± 1.2 months (range 2–17 months), and data were available for 17 patients. Table 3 compares symptoms after previous nonoperative treatments in terms of subjective patient factors with symptoms after operative resection. Nonoperative treatments are palliative; they do not remove the diseased portion of the airway and therefore need to be repeated frequently and often for life. Table 4 compares the subjective feelings of satisfaction regarding tailored cricoplasty versus previous nonoperative treatment. All patients

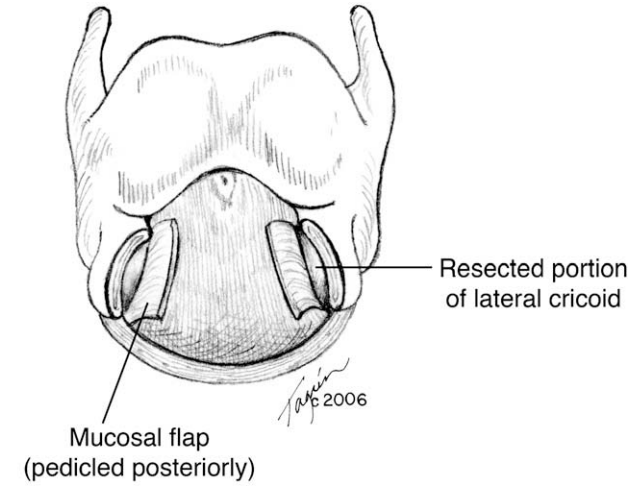

FIGURE 5. Cricoplasty, step 3. Mucosa overlying resected cartilage is persevered as pedicled flap.

reported that they were satisfied and would choose surgery again. Overall satisfaction was rated at 9.5 ± 1.0, and satisfaction ratings for resting and exertional dyspnea were 9.7 ± 0.5 and 9.5 ± 1.0, respectively. Symptoms of recurrence at follow-up were rated as 0.6 ± 1.4 out of 10.

Two patients (11.8%) reported a voice change after surgery. The postoperative voice in all patients is highly functional; however, the quality is changed. We put patients on voice rest for 1 postoperative week to decrease mucosal edema caused by movement of the cords and larynx.

DISCUSSION

Many techniques have been proposed to treat subglottic stenosis. These techniques range from endoluminal therapies to definitive surgical procedures.[1-13] Endoluminal therapies are palliative at best. Surgical resection of the abnormal tissue and reconstruction with healthy tissue is preferable and has been associated with good long-term results.[2] These reconstructive techniques yield the best results when an adequate laryngeal ventricle exists. Long-term results with laryngotracheal resection and reconstruction for idiopathic laryngotracheal resection and reconstruction have also been shown to be good to excellent.[4,5]

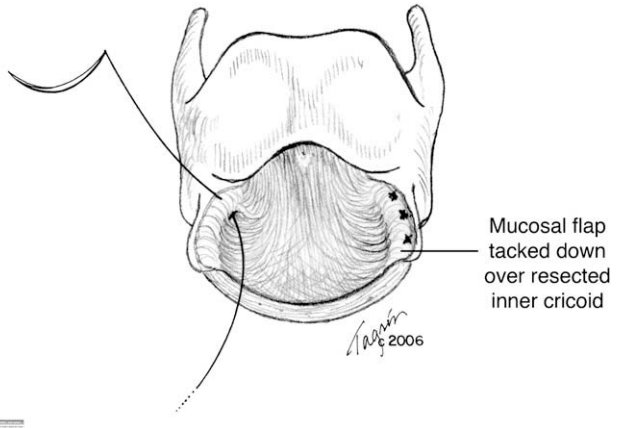

FIGURE 6. Cricoplasty, step 4. Exposed cricoid cartilage is resurfaced by advancing preserved mucosa as advancement flap over cricoid with interrupted 5-0 chromic sutures.

TABLE 1. Preoperative factors

Subjective severity (Likert scale 1–10)	
Mean ± SD	8.7 ± 1.0
Median and range	9.0 (7–10)
Previous operation (reoperation, No.)	1 (5.6%)
Previous endotracheal intubation (No.)	5 (27.8%)
Previous treatment for subglottic stenosis (No.)	12 (70.6%)
Previous dilation (No.)	8 (44.4%)
Previous stent (No.)	1 (5.6%)
Previous laser (No.)	9 (50.0%)
Previous mitomycin injection (No.)	2 (11.1%)
Previous tracheostomy or tracheal tube (No.)	3 (16.7%)

Dedo and Catten[13] reviewed their experience with 399 procedures to treat idiopathic subglottic stenosis in 50 patients. These procedures mostly consisted of repeated endoscopic laser submucosal resection and rotation mucosal flaps. Seventeen of the patients required permanent tracheostomy (34%), and Dedo and Catten[13] concluded that idiopathic progressive subglottic stenosis is a chronic, lifetime disease and that multiple procedures are required for palliation. We believe that this disease need not be palliated and can be cured with properly performed surgical resection and reconstruction.

Maddaus and coworkers[14] described a single-stage resection and reconstruction for subglottic stenosis. They used a telescoping technique in which they embedded the distal resection margin on the trachea into the remaining cricoid. They have had good results with this technique; telescoping the trachea into the cricoid compromises the luminal result, however, and this technique is not applicable to patients with lateral narrowing.

Subglottic resection and reconstruction achieve the best results when there is an adequate laryngeal ventricle. When a small ventricle exists and lateral narrowing is present, results are less predictable (Figures 1 and 8). Conventional techniques improve front-to-back narrowing; however, they do not address the side-to-side component. The resulting airway has a distinct oval configuration. The

TABLE 2. Postoperative complications

Total complications	6
Allergic reaction with respiratory distress	1
Clostridium difficile infection	1
Laryngeal edema and stridor	1
Urinary tract infection	2
Rash	1
Patients with complications	5

TABLE 3. Subjectively reported symptoms before and after cricoplasty (Likert scale 1–10)

Symptom	Preoperative	Postoperative	*P* value
Dyspnea			
At rest	6.1 ± 2.4	0.5 ± 0.8	<.001
With activity	8.6 ± 1.3	1.0 ± 2.0	<.001
Wheezing severity	7.3 ± 2.2	0.4 ± 1.2	<.001
Coughing severity	6.8 ± 2.1	1.0 ± 1.4	<.001
Noisy breathing	7.8 ± 2.2	0.5 ± 1.1	<.001
Stridor severity	2.9 ± 4.2	0*	.010
Inability to clear secretions	3.0 ± 4.0	0.1 ± 0.2	.007
Difficulty swallowing, lump in throat	1.8 ± 3.3	1.1 ± 2.4	.226
Impact of disability			
Day-to-day activity	7.6 ± 2.4	1.5 ± 2.5	<.001
Work activity	7.0 ± 3.0	0.6 ± 1.3	<.001
Social activity	5.9 ± 3.4	0.6 ± 1.1	<.001
Blocks patient can walk without dyspnea	1.2 ± 2.0	23.9 ± 17.6	<.001
Stairs patient can climb without dyspnea	1.6 ± 2.4	85.1 ± 192.7	.102

*No postoperative stridor reported.

results, although an improvement on the preoperative situation, are less than ideal. Tailored cricoplasty was developed to allow increased postresectional luminal diameter by increasing the width as well as the anteroposterior diameter of the subglottic airway. The typical subglottic airway is 5 × 5 mm (19.6 mm^2) at presentation. The normal dimensions of the subglottic airway are at least 10 × 12 mm. If the anteroposterior diameter is improved to 10 mm and the lateral narrowing remains at 5 mm, the new cross-sectional area is 39.3 mm^2. If the width can be increased from 5 mm to 9 to 10 mm, the new cross–sectional area doubles (78.5 mm2). The preserved mucosal flap, which is tacked down over the exposed cartilage, helps with healing and prevents granulation tissue from forming in the airway at the anastomosis. Figure 7 outlines the luminal increase in area that can be gained with the cricoplasty technique. By increasing the

TABLE 4. Subjective feelings of satisfaction for surgical and previous (nonoperative) treatments (Likert scale 1–10)

	Nonoperative	Operative	*P* value
Overall effectiveness	6.4 ± 3.9	9.7 ± 0.7	.247
Overall satisfaction	5.0 ± 3.8	9.5 ±1.0	.122
Symptom improvement satisfaction			
Dyspnea at rest	3.4 ± 4.4	9.8 ± 0.5	.241
Dyspnea with activity	5.2 ± 3.8	9.7 ± 0.9	.542
Wheezing	3.5 ± 3.8	10.0 ± 0.0	—
Cough	5.2 ± 4.1	9.5 ± 1.0	.759
Noisy breathing	4.8 ± 4.1	9.8 ± 0.4	.333
Stridor	1.2 ± 3.1	2.9 ± 4.7	.342
Secretions	1.8 ± 3.4	4.7 ± 5.1	.416
Swallowing	0.8 ± 2.4	2.1 ± 3.6	.102

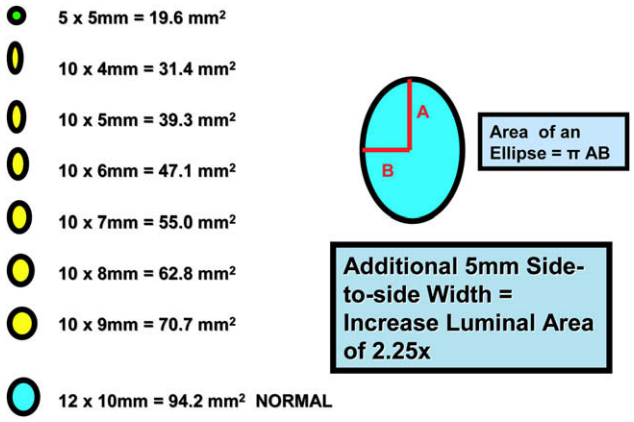

FIGURE 7. Luminal area gained with cricoplasty technique. By increasing lateral width of airway by only 5 mm. luminal diameter is increased 2.25 times (from 31.4 mm^2 to 70.7 mm^2). This provides significant improvement in air flow.

lateral width of the airway by just 5 mm (as shown in Figure 7), the luminal area can be increased 2.25 times (from 31.4 mm^2 to 70.7 mm^2). This provides significant improvement in airflow.

The results of our retrospective study with telephone follow-up of patients who have undergone this novel technique demonstrate favorable outcomes after resection. Our patients often had postoperative voice changes; however, they were usually able to speak well. We have seen few complications with this technique, and it appears to be both reproducible and durable; however, we do not yet have long-term follow-up. None of the patients in this series had positive results for ANCA. Patients with ANCA positivity are usually excluded from resection because of the association between ANCA and Wegener granulomatosis.[15] Patients with Wegener granulomatosis are treated with dilation, steroid injection, and systemic therapy.[16]

None of the 18 patients in this initial report of tailored cricoplasty required reoperation, tracheostomy, or readmission

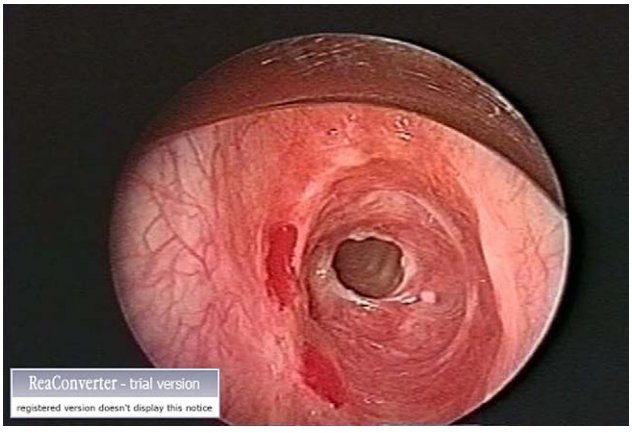

FIGURE 8. Tight subglottic stenosis. View is from larynx during rigid tracheoscopy.

to the hospital during the entire follow-up period. All patients reported that they were satisfied and would choose surgery again. Overall satisfaction with the procedure was extremely high (9.5 ± 1.0), and satisfaction ratings for resting and exertional dyspnea were also high (9.7 ± 0.5 and 9.5 ± 1.0, respectively). Symptoms of recurrence at follow-up were extremely low (0.6 ± 1.4 out of 10). Dramatic improvements were observed between subjectively reported symptoms before and after cricoplasty.

Tailored cricoplasty is an effective technique to improve the outcome of reconstructive subglottic stenosis in the short and medium term. It offers reconstructive possibilities for patients previously considered to be the most challenging subset of those with subglottic stenosis.

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Discussion

Dr Erino A. Rendina *(Rome, Italy).* First, I congratulate you on an excellent experience. Eighteen tailored cricoplasties in 15 months is an outstanding experience, and the results are very good.

In your series, predictably, the vast majority of patients had idiopathic subglottic stenosis. These patients are the most difficult to treat, and they are notoriously vulnerable to recurrence. This type of stenosis is usually short, and although I concur with the prudential measure of keeping the patient's neck flexed for 1 week, as stated in the article, this entailed a lack of release maneuvers in your series. Despite the idiopathic nature of the stenosis, you did not have any remarkable complication or recurrence, and this is an exceptional achievement. The only postoperative problems arose from mucosal edema, which might be of particular severity at such a high airway location, as stated in your article.

I have three questions. First, your modification consists of enlarging the airspace laterally, whereas the classical repair, the Pearson repair, prescribes the posterior resection of the cricoid plate beneath the mucosa. How often were both enlargement techniques needed simultaneously to obtain an adequate airspace?

Dr Liberman. Thank you for your comments. In terms of getting the posterior cricoid plate exposed and removing thickened tissue, I don't have the exact numbers for this experience, but it's done approximately half the time. For most of these patients, as we said, the issue is that the stenosis is high and they have a severe side-to-side narrowing. The anteroposterior dimension is quite easy to fix. Once you remove the anterior portion of the cricoid, your anteroposterior dimension is improved. We have no hesitation in removing the posterior cricoid plate and resurfacing that, however, which is much simpler than fixing the side-to-side narrowing.

Dr Rendina. You stated that you extubate your patients in the operating room at the end of the procedure, yet you mentioned in your article that in one case emergency reintubation was required for sudden mucosal edema. Our habit at my institution is to keep the patient intubated, fully awake, under spontaneous breathing, with the tube uncuffed for 24 hours. This may be unpleasant for the patient but may minimize the effect of early mucosal edema. In addition, you do not administer steroids routinely in the postoperative period, yet you were occasionally obliged to institute steroid therapy for acute causes. On the basis of this experience, would you now consider some kind of early postoperative airway protection and routine steroid prophylactic therapy for these high airway procedures? Thank you again, and congratulations.

Dr Liberman. Thank you. I'll start with the endotracheal intubation question. We do not routinely keep patients intubated postoperatively, whether with the cuff up or down, and have found little problem with that. Of our 2 patients with airway complications, one of those patients was reintubated. The patient did very well after surgery, and at 7 postoperative days had an allergic reaction to a new shampoo in the shower. The patient had a difficult airway and because of that was reintubated in the intensive care unit. The patient was actually preparing to go home the day that the event occurred. The patient had undergone bronchoscopy that day in the operating room just to look at the anastomosis, which we do on day 7 for all patients, and the anastomosis was fine. The shower took place later that day. The patient had to be reintubated over a bronchoscope. That was her issue. So I don't think that that was necessarily related to edema, as opposed to an anaphylactic reaction in the airway.

The other patient had postoperative mucosal edema and was treated with intravenous steroids and did not need reintubation. Probably having a tube placed in that patient would have been safer; however, she was able to get by without it. We do not routinely use endotracheal intubation for fear of irritating the anastomosis, and we rarely see airway complications in these patients. This series

constitutes only the 18 tailored cricoplasties that were performed during that 15-month period. Another 30 or 40 patients underwent subglottic resections without cricoplasty during that period, and none of those patients required either steroids or intubation.

Dr Joel D. Cooper *(Philadelphia, Pa).* I enjoyed the article; it explained something that I have not quite understood before. I've had the same experience since coming to Philadelphia, I think that in the last 18 months there have been about 20 laryngotracheal resections, with 15 or 14 for idiopathic stenosis. I would have to disagree that the usual narrowing is anteroposterior. The picture you showed me is the absolutely typical, usual concentric narrowing of the idiopathic subglottic stenosis, and I have not seen one case of narrowing that wasn't circumferential, where it was front to back. So I really believe that that is typical.

What I now understand, and the question I will ask, when Dr Pearson described this operation, and I was fortunate to be tagging along at the time, the operation that he described uses either a rongeur or a dental burr to take out the posterior cricoid plate, saving the posterior perichondrium, adding a tremendous amount of increased diameter. Part of that procedure is to go right up the sides, as you described doing separately, and take out the cartilage, leaving the perichondrium, the outer perichondrium. That's the reason, as Dr Pearson described it, that you advance the entire trachea, either by closing the membranous wall and advancing the entire trachea with a closed membranous wall or usually just by advancing the whole trachea into that space. You have accomplished this by doing what you described here, but doing it posteriorly. Dr Grillo described taking a membranous flap of the membranous trachea, taking off one ring. The difference was, I believe, that he didn't remount as much circumferentially and therefore advance the mucosal flap for resurfacing, with slightly less advancement of the trachea. So I really think that if you just remount with a burr or a rongeur the posterior plate of the cricoid, and it usually goes up at least halfway around the cricoid to include the areas that you have, you can just very easily then advance the entire trachea as originally described, and I don't think it has to be selectively just on individuals who are seen to have a side-to-side stenosis. I don't know if my understanding is correct, but is it correct, by and large, that your standard procedure does not involve removing a great deal of the posterior cricoid plate?

Dr Liberman. I would like to go back to the beginning and talk about the radiograph that we showed. I agree that most patients have concentric narrowing; this becomes a problem, however, when you get very high, and we're talking about at the top of the cricoid as opposed to the lower ones. When it's at the lower edge of the cricoid, it's fine, because you don't need to worry about it as long as you remove the lower part of the cricoid. When you're up at the larynx or at the thyroid cartilage, however, which is what that radiograph was showing, those patients have really, really high stenosis. Even if you resect the posterior part, because the stenosis is so tight from side to side and is so high, you cannot remove the whole posterior cricoid without compromising postoperative laryngeal function and the recurrent nerves. These are the patients that we're describing, and maybe I didn't make that clear, but they are the ones in whom you really need to resect that submucosal thickened tissue, the ones who can't be helped when approached from below. In terms of the original Pearson procedure and telescoping the trachea up into the area, that is very effective. When you get very, very high, however, in these types of patients you're limited by the fact that you still have stenosis even after you've taken out the anterior cricoid and the posterior cricoid, because the stenosis really continues up to an area that a lot of people would have considered inoperable in the past. They actually have stenosis in the larynx, and by telescoping a piece of trachea up into an already thick and small airway, you would decrease the luminal diameter even more. So those are the patients we're trying to help with this procedure. We still do the typical procedure, not the Pearson procedure but the Grillo procedure, for the majority of patients, who don't have that type of disease.

Dr Paolo Macchiarini *(Barcelona, Spain).* Thank you for this interesting new technique. The typical Grillo technique is a wonderful technique, and this seems to be wonderful as well. Would you please, however, describe further the precise indications? In my experience, finding the right plane between the anterior and posterior arch to do the submucosal tailoring is extremely hard. The vast majority of these patients, probably those with known idiopathic stenosis, have a destroyed or almost destroyed cartilage structure, making the plane difficult to find. Should this technique be restricted, as you mentioned as well, to patients with this very high located idiopathic stenosis or the untreated simple postintubation subglottic stenosis? Also, did you ever try for patients with such high stenosis to inject high doses of steroids into the vocal cords either before or after operation avoid any problems?

Dr Liberman. First, as to the steroids, we have not given any, and we usually have not seen vocal problems. That would be the answer to the second question. For the first question, we continue to use the typical Grillo technique for most patients. We choose to use the tailored cricoplasty as opposed to the typical Grillo procedure for the patient who does not have a good luminal airway diameter after resection with the Grillo technique. So we've done the Grillo procedure, and now the patient still has maybe a 10-mm anteroposterior diameter, but the side-to-side diameter is still 4 mm. Putting it all back together is daunting, as you can imagine. Those are the patients for whom we use this technique. In contrast, if we do the anterior and posterior resections and the opening looks wide, we just sew it back together in the way that was originally described.

With respect to the plane that you were asking about, there is no plane, as you mentioned, and it's very hard to find the tissue plane. We use a sharp dissection. Actually, we don't find the plane, we make the plane. The submucosal thickened tissue, as you mentioned, is completely abnormal. There is no submucosal plane. There is no plane between that tissue and the cricoid. We use sharp, slow dissection, taking pieces off 3 to 4 mm at a time, until we feel that the cricoid is not compromised too much. We still have integrity and strength of the cricoid to hold the airway together as well as having an increased luminal diameter. So that's the answer to that question.